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SOME PROBLEMS OF TYPIFICATION AND UNIFICATION

OF DEVICES FOR TECHNOLOGICAL CONTROL AND

REGULATION USING NUCLEAR RADIATION

By

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An important role in solving many problems of complex
industrial mechanization and automation in the USSR is played
by devices for technological control using nuclear radiation.

As is well known, the automation of industrial technologi-
cal processes is based on the extensive use of typified as-
semblies, units, production lines, etc. Work on the typification
of radioactive devices for automatic control and regulation has
been carried on for the last few years.

Among the highly diversified specialized technological
control devices based on the application of radioactive ra-
diation, typification principles have found the widest appli-
cation in position-control and regulation equipment using relay-
action devices, and in gauges for measuring the thickness and
density of coatings employing differential and compensation
circuits.

Position-control methods using radioactive isotopes are
based on registering drastic changes in the intensity of radio-
active radiation absorbed or scattered by the medium irrespecti-
ve of the specific features of the parameter controlled. The
accuracy of estimating the parameter controlled with the aid
of relay-action devices depends slightly, if at all, on the
intensity of the radiation registered.

Proceeding from this general principle of action, it is
possible to work out general principles for designing record-

ing devices which would allow to carry out the typification of

their individual elements. A characteristic feature of radioac-

tive relay-action devices which greatly influences their prin-

cipal characteristics such as sensitivity, response and relia-

bility, consists in fluctuation processes arising in the devices

and associated with the statistical nature of radioactive ra-

diation. Therefore general-purpose relay-action devices designed

to handle a great diversity of problems in various industries

contain electrical adjustment elements which permit setting up

an optimum regime of device operation under the specific con-

ditions of the process controlled.

Typified relay-action devices operate in the regime of

registration of average current of a radiation detector (low-

voltage, gas-discharge, halogen counters).

The principle of typification of relay-action devices

consists in dividing them into three separate typified ele-

ments: radiation sources, radioactive sensing elements contain-

ing a radiation detector, and general-purpose electronic relay

units.

Devices of different designations are provided with

different sensing elements which are specialized. The design

of the sensing elements ensures a maximum versatility of

their utilization in solving typical technological problems

in various industries.

By way of example, below we describe some specimens of

typified assemblies of relay-action equipment.

The radioactive detectors (I) and (2) in Fig. I are

designed to register hard beta and soft gamma radiation. They

are employed in controlling, counting and interlocking devices.

Such detectors are widely used, for instance, in arrangements

which control the filling of containers regardless of the
nature of the product contained in them, keep account of the
output of stamping and pressing equipment, ensure protective
interlocking of multiposition automatic presses, etc. These
detectors are used in the chemical, food, mechanical engi-
neering and other industries.

The radioactive detector 3 (Fig.I) is used in devices
for radioactive labelling of steel wire butt welds. To secure
a reliable control during the passage of separate wire coils
in umultiple - drawing machines, the weld butts of the wire
coils are labelled with radioactive phosphorus - 32. The
detector 3 is set up before the last die; it contains gas-
discharge counters which register the passage of the labelled
weld butt. Registering devices control a multiple - drawing
machine and electromechanical shears for coil separation. The
detector is used in the metallurgical industry.

The radioactive detectors (4), (5) and (6) (Fig.I) are
employed in devices for position control of the level of
liquid and loose materials. The detector 4 is designed to
register hard beta radiation and serves to control the
filling of measuring vessels with liquids. It consists of
a metal cylinder provide with a counter with a beta source
rigidly attached to it by means of a bracket.

The detector is immersed in the vessel to a preset
depth. The level is controlled by the attenuation of the
radiation due to the presence of the liquid layer between
the source and the counter.

The detector (5) is designed for directional registra-
tion of gamma radiation. It is used in devices controlling

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the level of a liquid by means of a radioactive float
with Co^{60} or Cs^{137} sources. The detector consists of a
metal body containing a halogen counter and a one sided
widge-type lead collimator. The detector is attached by
means of a flange on the external side of the vessel at
a preset filling level.

The detector (6) is designed to register gamma radiation
in gauges controlling the level of liquid, loose and lump
materials by gamma-raying vessels filled with them. It
contains a number of gas-discharge halogen counters lo-
cated in one plane. This device is used in gauges for
technological level control in various industries: chemi-
cal, mining, ore-dressing, construction materials, etc.

In addition to the above-enumerated instruments,
unified sensing devices of several types are produced
which are designed for contactlers three-position regist-
ration of the readings of measuring instruments of various
types (needle instruments, flowmeters, liquid thermometers,
etc).

No. 7 in Fig. I denotes a general-purpose electronic
relay unit which is used in relay-action devices.

Typified assemblies for relay-action devices are pro-
duced in three types: normal, explosion - proof and airtight.

Methods for contactless control of thickness and
coating thickness and density are based essentially on
two types of continuous-action devices. Devices of the
first type are based on a differential circuit for
comparing the material controlled with a standard specimen,
and are designed to control materials in continuous tech-

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nological processes. Devices of the second type are built
as self-compensation circuits with continuous counting
of the parameter controlled, and are meant for material
control both in continuous and intermittent technological
processes.

Both types of instruments mostly use ionization
chambers as radiation detectors. They are characterized by
high versatility and a wide range of the values measured,
and may by employed for controlling materials which differ
in their chemical and physical properties.

Use of beta radiation requires open ionization chambers;
in the case of gamma radiation high-pressure chambers are
employed. Scintillation counters with current conditions of
electronic photomultiplier operation are also used occasio-
nally.

Fig. 2 shows the functional diagram of a device of the
first type. The difference in the currents induced by two
radiation fluxes is measured by means of a differential
ionization chamber cosisting of two electrically cross-
connected compartments (I and 2) with a high - ohmic
resistor(3). One flux from the source (4) passes through
the material controlled (5) and enters the principal com-
partment (I). The other flux from the auxiliary source (6)
enters the compartment (2) through the standard specimen
of the material controlled (7). The differential current
is intensified by one amplification cascade (8) operating
in an electrometric regime, and is fed to the measuring
instrument (9). To eliminate the instability of zero count,
the instrument is provided with a periodic self-adjustment

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arrangement which uses the above- described unified assemblies of relay devices. Periodically, once every 30 - 60 minutes, the time relay (10) switches the device circuit from the measuring to the self - adjustment regime. The switch (II) closes the input of the electrometric cascade. If the measuring instrument needle is not reset to zero, the beta radiation from the isotope located at the needle tip penetrates into one of the gas-discharge counters (12) installed behind the instrument scale and separated by the metal shield (13).

The counters are connected with the typified two-channel electronic relay unit (14) which phase-commutes the supply voltage of the windings of the servomotor (15). The latter is connected mechanically with the potentiometer which sets the measuring instrument to zero.

Self-adjustment takes about 1 minute, after which the instrument circuit automatically switches over to the measuring regime.

The circuit response is selected so that the needle deflection to the extreme left and reght positions corresponds to the tolerance for the deviations of the parameter controlled. Signalling for the extreme positions of the needle is effected with the aid of the two counters (16) located at the extremes of the measuring instrument scale. The counters are connected with the typified two-channel electronic relay unit (17). The instrument is provided with terminals which connect it with a system for the regulation of the process controlled, a standard recording instrument and a sounding or light alarm which announces the overshooting

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of the parameter controlled. The general view of the device is given in Fig. 3.

The device consists essentially of two units: the radioactive detector (I) with a differential ionization chamber, and the measuring unit (2). The device operates without self-adjustment and requires periodic manual adjustment. The self-adjustment system includes two typified units: the time relay (3) and the two-channel electronic relay amplifier (4). The external signalization system supplements the device with another two-channel electronic relay unit (5). Three of the five principal units of the device are employed in relay-action instruments as typified assemblies. Therefore, plants which have mastered the production of relay-action devices, have easily handled small-scale production of such devices. The device is designed to control and measure the surface density of materials in the range from 10 to 10,000 gm/sq.m. The measurement accuracy is not below 1%.

Fig. 4 demonstrates the functional diagram of a device of the second type. This circuit also employs a differential ionization chamber.

The radiation from one of the sources (I) passes through the material controlled (2) and penetrates into the principal chamber compartment (3). The radiation from the auxiliary source (7) through the orificing shutter (6) enters the compartment (4).

The signal proportional to the differential current of both the chamber compartments is intensified by the amplifier (10) and fed to the servomotor (II) which shifts

the orificing shutter (6) until a complete equality of
currents in both the chamber compartments is achieved.
The position of the orificing shutter is registered by
the indicator (12).

To eliminate the drift inherent to d.c. amplifiers,
the device uses modulation (interruption) of the output
signal of the chamber with the aid of the converter (9)
followed by the a.c. amplifier (10).

Inasmuch as the device uses a differential ionization
chamber, the instability of the chamber supply voltage
and the pressure variations in both of its compartments
do not affect the measurement results. Besides, the varia-
tions in the high-ohmic resistance and in the amplification
factor of the amplifier do not introduce considerable
errors into the measurement results, either.

The indicator (12) has the shape of a needle measur-
ing instrument. The angle of needle deviation is a measure
of the intensity of the radiation flux measured. The scale
is calibrated in units of thickness or surface density
of the materials measured.

The general view of the device is presented in Fig. 5.
The device is designed for continuous measuring and recording
of the surface density of sheet materials in the range from
10 to 10,000 gm/sq.m. The measurement accuracy in not below
1%. The device is provided with a terminal leading to the
system of automatic regulation of the process controlled.

Both the types of devices may be used to measure
coating thickness; in this case special sensing instruments are

employed whose function is based on backscattering of beta radiation. The other assemblies of the instrument remain unchanged.

The wide range of the values measured is attained by using a set of standard radioactive sources in both types of instruments.

Some of these sources are used in position-control devices as well.

Table I contains characteristics of typical radiation sources which have found the widest application in technological control devices.

Fig. 6 exhibits sketches of typical beta-source containers used in industrial technological control devices.

The work carried on in the USSR toward the typification and unification of devices for automatic control and regulation of industrial processes using radioactive radiations, and the industrial production of typified general-purpose units for them have allowed to proceed from single separate operations to complex automation and mechanization of large plants.

Thus, for instance, at the Mining and Milling Combine in Krivoy Rog over 60 relay-action devices have been installed which automatically control and regulate a great number of labour-consuming processes and operations.

The introduction of radioactive automation at the Combine has essentially improved labour conditions and ensured an economy of over 10 mln. roubles per year.

The utilization of devices for position control and regulation with radioactive sensing elements for the automation of underground works in the coal and mining indust-

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ries is highly efficient. It allows to relieve a great
number of underground workers.

The application of gauges measuring thickness, coating
density and thickness, also ensures high economic efficiency.

Thus, the introduction of gauges for measuring the thick-
ness of non-ferrous sheet metals at one of the Leningrad
plants has allowed to reduce the expenditure of raw materials
due to the reduction of tolerances and the decrease in rejec-
ions from 4.4 to 1.4%. Simultaneously the productivity of
rolling machines has increased by 7%. The total annual
economy at the plant amounts to 10 mln. roubles.

The reduction of tolerances for the thickness of sheet
materials, such as paper, glass, plastics and others, by
installing technological control instruments allows to great-
ly economize materials, to increase the productivity of
the operating equipment, and provides conditions for switch-
ing over to completely automatized production in a number
of industries: metallurgical, chemical, paper, etc.

The examples cited above reveal that the application
of technological control devices using nuclear radiation
has a great economic effect. According to the economists,
of the total annual economy obtained in the USSR in 1958
due to the utilization of radioactive isotopes and nuclear
radiation (1.6 - 1.8 mlrd. roubles), the radioactive
automatic control devices contributed about 500 mln. roubles.
during the same period.

We believe that in the near future the efforts will
de directed at a further typification of instrument ele-
ments and the extension of typification principles to

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devices for measuring liquid density, flow rate meters,
pressure gauges, etc.

It has been estimated on the basis of the established
technical possibilities and the scope of the prospective
applications of radioactive devices for the automatic
control and regulation of technological processes, that
within the next few years the economic efficiency of
their utilisation in the national economy of the USSR
will achieve a considerable magnitude.

T a b l e   1

Isotope	Promethium-147	Thallium-204	Strontium-90, yttrium-90	Zerium-144, praseodi-mium-144	Thulium-170	Selenium-75	Cesium-137	Cobalt-60
Half-life	2.66 yrs	4.26 yrs	27.7 yrs	284 d	129 d	125 d	30 yrs	5.24 yrs
Type of radiation (used)	β	β	β	β	γ	γ	γ	γ
Radiation energy (used,MeV)	0.223	0.765	2.18	2.27	0.084	0.3	0.662	~1.25
Source activity (mc or mg-eq of radium)	1-100	1-100	0.02-100	1-100	2-100	10-100	0.1-500	0.1-500

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FIGURES

Fig.1. Typical assemblies of relay-action devices.

1, 2, 3, 4, 5, 6 = radioactive detectors; 7 = general-purpose electronic relay block.

Fig. 2. Differential circuit for measuring material thickness and density with periodic self-adjustment using relay-action devices.

Fig. 3. General-purpose radioactive thickness and density gauge based on a differential circuit for comparing material controlled with standard specimen.

1 = radioactive detector; 2 = measuring unit; 3 = time-relay unit; 4,5 - typical two - channel electronic relay amplifiers.

Fig. 4. Self - compensation circuit for measuring material thickness and density.

Fig. 5. Radioactive general-purpose thickness and density gauge with continuous counting of parameter controlled.

1 = measuring unit; 2 = amplifier and supply circuit; 3 = indicating instrument.

Fig. 6. Standard beta- source containers.

1 = point source container; 2 = plane source container; 3 = linear source container.
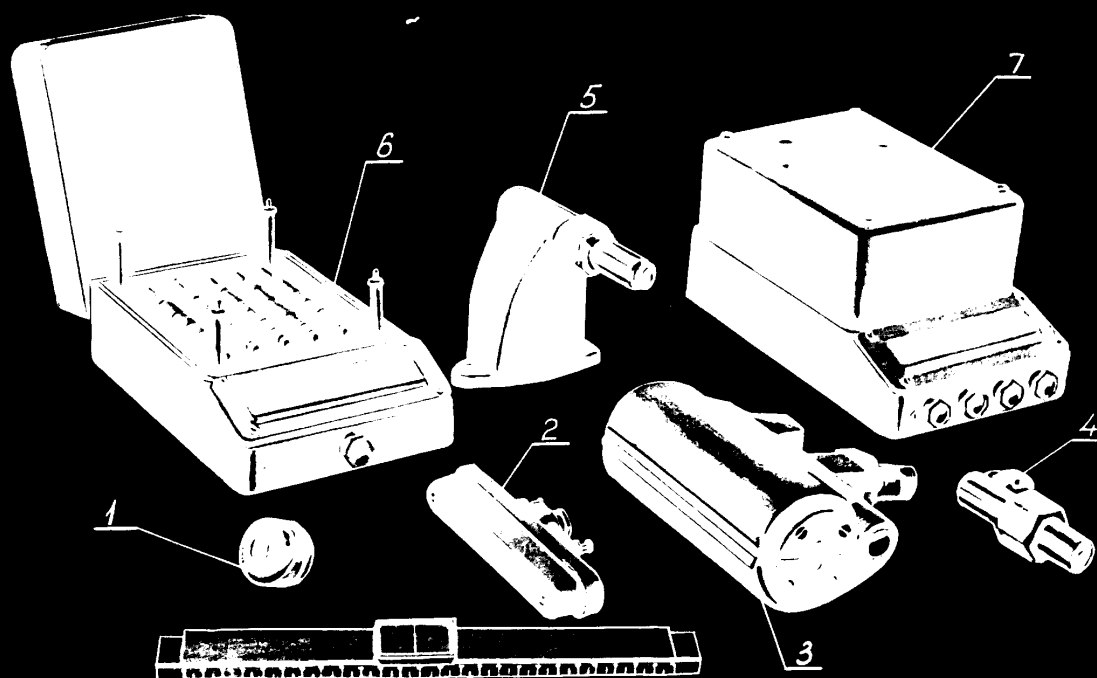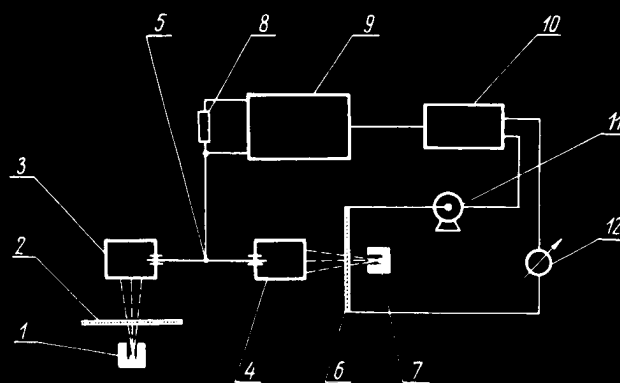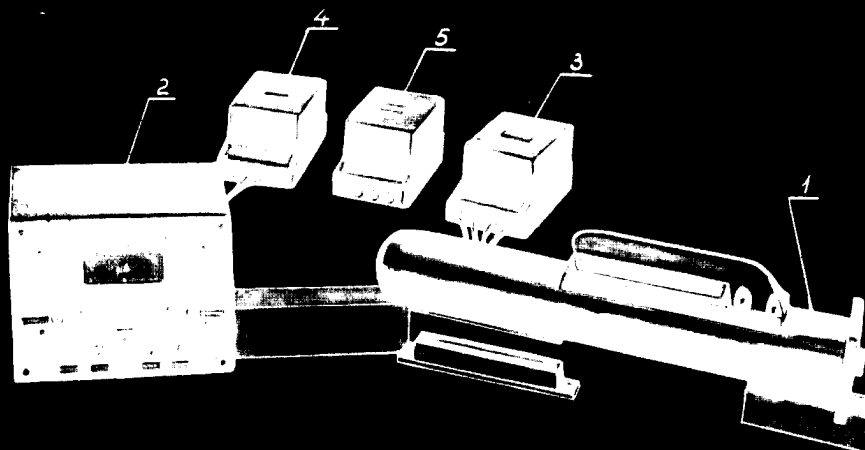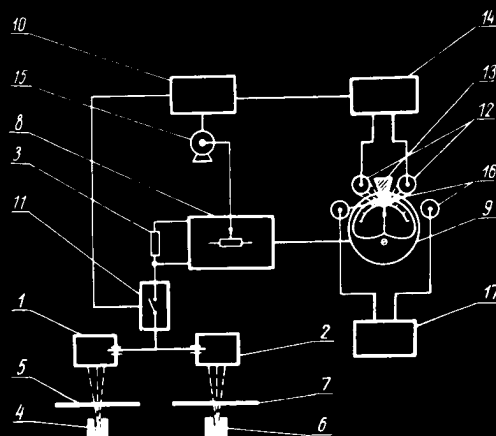
Рис. I

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Рис. 5

a

11

19

1.

a

d

7

10

D

2

$d - 10, 20, 30, 40, 50$ мм

$D - 22, 32, 42, 52, 62$ мм
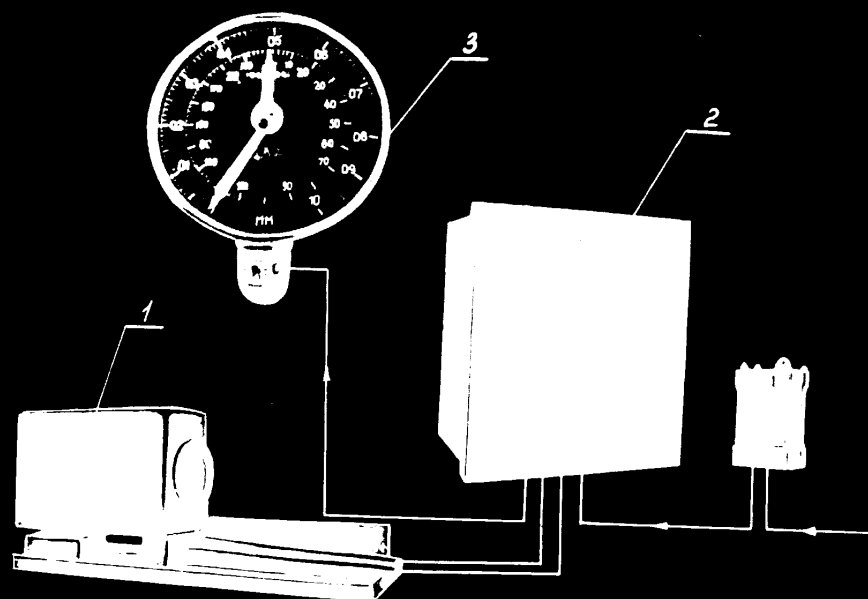
a

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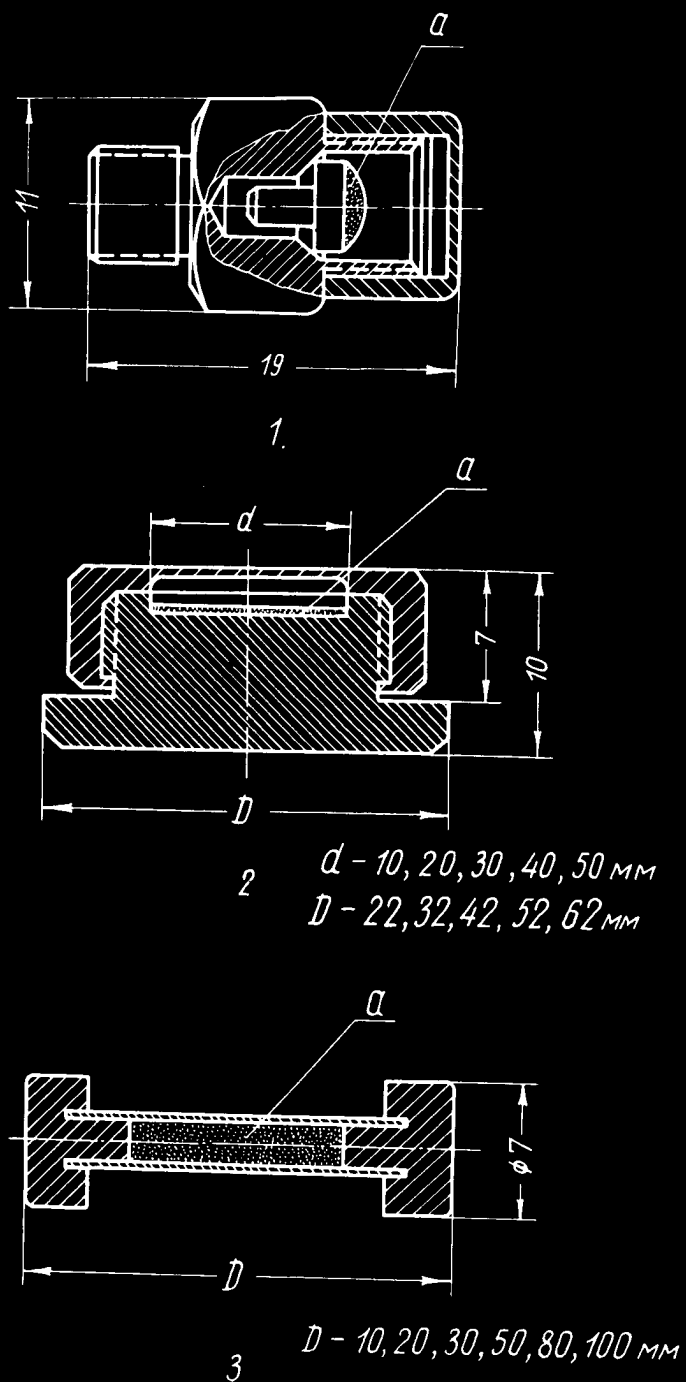
D

$D - 10, 20, 30, 50, 80, 100$ мм

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Рис. 6

THE USE OF RADIOACTIVE ISOTOPES AND NUCLEAR RADIATION

IN THE SOLUTION OF SOME PROBLEMS OF BLAST-FURNACE AND

STEEL-MAKING PRODUCTION

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The extensive organization of work in metallurgy, in
which the attainments of nuclear physics have been utilized,
in the USSR dates back to the years 1948-1949.

The Institutes and plants of the Ferrous Metallurgy
have a network of radiometric laboratories for the inspection
and development of technological processes.

Separate questions connected with the utilization of
radioactive isotopes and nuclear radiation in the metallurgical
industry of the Soviet Union have been described in the
literature in detail. Some results have already been reported
at international conferences. The present report deals only
with individual examples of the utilization of radioactive
isotopes and nuclear radiation in the ferrous metal industry.
Chief attention is paid to the results of work now in progress
at the Kuznetsk Iron and Steel Works, and the "Azovstal",
the Dzerzhinsk, the Ilich and the Stalinsk Iron and Steel
mills, with the collaboration of the Central Scientific Resse-
arch Institute of the Ferrous Metal Industry.

I. BLAST-FURNACE PRODUCTION

1. Regulation of Incoming Charge in Blast-Furnaces

In the field of cast iron manufacture the automation
of the control of the operation of the blast-furnace process

is an important problem. In this connection there arises the
need to provide contactless, continuous-acting low-inertia
data units, which afford data on the run of processes, as
well as   its transmission into the computer. In the
solution of this problem in the Soviet Union great attention
is paid to the utilization of radioactive isotopes. To that
end there has been developed a radiometric installation de-
signed for the regulation of blast-furnace incoming charge.

At the present time the blast-furnace incoming charge is
regulated on the basis of indications of mechanical soundings,
which give satisfactory results only when the blast-furnace
runs smoothly. Sounding diagrams often do not characterize
the position of the surface of the charge and do not permit to
regulate the level of filling. Great difficulties are experi-
enced when mechanical soundings are utilized in the operat-
ion of large volume blast-furnaces,when the pressure under
the furnace top is raised.

The radioactive method regulating the level of filling
of the blast-furnace with charge materials is based on the ab-
sorption of gamma-rays from radioactive sources. In the given
case one may utilize radioactive isotopes of cobalt and other
elements with a hard gamma-radiation (with energies of 1 MeV
or more) and with a sufficiently large half-life (one year and
more). Closed sources of radiation with activities of about
200 mcuries (depending upon ray hardness and furnace dimen-
sions) are set up in the furnace refractory masonry at a
definite level of fill of charge materials, or under the bell
(Fig. 1). At various points along the furnace periphery in the
refractory masonry radiation detectors (halogen counters) are

installed, whose cables are connected to the recorder with a light panel. Detectors are set up on a number of horizons, four on each horizon. When the charge material level of fill is lower that the location of any one of the detectors, the irradiation intensity of the detector increases abruptly, and the respective signal lamp on the control board ignites.

The radiometric method of regulation of the level of filling is being used on one of the blast-furnaces of the Dzerzhinsk plant. The diagram of the radiometric regulator of the level of filling, developed by personnel of the plant, of CSRIFMI and of the Ukrainian Institute of Metals, is shown on Figures 1 and 2. In this case two sources of radio-active cobalt, 500 mcuries each, were placed on the blast-furnace, under the level of the material, along the furnace top circumference, between the vertical rows of counters (See Fig. 2). Sources and counters have been arranged in such a manner that the radiation of each source acts only upon the two vertical rows of counters, which are opposite to it. The possibility of shifting the sources in pipes permits to carry it out with fascility.

A comparison of the readings of the radiometric instal-lation and of the mechanical soundings leads to the following conclusions:

a. The readings of the installation from the side of the cast iron tap and air heaters rarely coincide with sounding data when the furnace runs very smoothly; as a rule, the read-ings of mechanical soundings are considerably lower than the surface of the fill, as revealed by radiometric control;

b. Due to the fact that the soundings are drawn in by the charge, the actual level of materials is in many cases higher

that the bottom position of the edge of the large bell; as a
result, the orientation by mechanical sounding readings often
leads to the overloading of furnaces. The passage to the con-
trol of the loading of furnaoes by radiometrio control data
evens out the running of furnaces.

The new regulator of filling clearly manifests a nonuni-
form speed of incoming materials along the circumference.

The Dzerzhinsk Plant, CSRIFMI the Ukrainian Institute
of Metals and the Tallin   measuring instruments plant
have worked out an industrial standard for the radiometrio
fill regulator. During the years 1959 and 1960 regulators will
be installed on blast-furnaces at a number of plants.

2. Control of the Quality of the Charge and Ore

In order to control the blast duty a reliable and quick
determination of the granulometrio composition of the charge
is needed. At some plants the screen oomposition of charge
materials is determined by the screen sizing of samples
weighing about one ton, selected in 24 hours. This very labo-
rious method does not offer any possibility to obtain in the
time alloted to it the necessary true results, which conside-
rably lowers its validity.

The study of the absorption of gamma-radiation by the
blast-furnaoe charge components carried out on the Dzerzhinsk
and Novo-Tulsk Steel Plants revealed the possibility of con-
trolling the gas-permeability of charge materials by the ra-
diometrio method. It has been found that the absorption of
gamma-rays in that case depends upon the density, the bulk
weight of the material connected with the screen composition.
Personnel of the CSRIFMI and of the Dzerzhinsk Plant develo-
ped and manufactured three experimental devices for the measu-

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rement of the lumping of coke, upon whose screen composition depends the general gas-permeability of the charge column (coke occupies about 60% of the charge volume).

The device has been installed at one of the blast-furnaces of the Dzerzhinsk Plant, at the left-hand weight funnel of the lift of the blast-furnace. The weight funnel a (Fig.3) is transluced by a radioactive isotope of cobalt (Co^{60}), with a 300 mcurie activity, situated in a protective collimator b, which may be displaced by guides, either bringing it closer to the funnel, or removing it from the funnel. The data unit d, located on the opposite side, from centres at the point e consists of eight CTC-6 counters. It measures the intensity of the beam of rays, which passes through the coke, which is recoreded by a specially constructed recorder.

Coke lumping is recorded separately for each skip by its filling the weight funnel, simultaneously with the stoppage of the disk sieve, which delivers coke from the hopper into the funnel. In making records on the band appear "peaks" of the radiation intensity (Fig. 4) varying in size, depending upon the density of the material.

A comparison of records of the device, obtained at the Dzerzhinsk Plant, with readings of furnace operation, has revealed that the absorption of gamma-rays by coke varied from 5.0 to 12.7% of the mean value; at a minimum absorption the coke ore load reached 2540 kg/t and at a maximum it was lowered to 2210 kg/t., that is, it was lowered 13%. That does not agree with the existing ideas on the possible effect of coke lumping upon the thermal condition of the furnace and of coke consumption (the amount of carbon in the charge hardly changes thereby). Furnace operation observations reve-

aled that at periods of maximum absorption of gamma-rays by
coke the extraction of coke out of the furnace with slag
increases (not only with the lower, but also with the upper
slag). Individual cast iron yields were followed by the
carrying away of approximately up to 10-12 tons of coke with
the lower slag; a considerable amount of coke fell into slag
ladles through slag taps. Since the coke left the hearth
heated to 1350-1400°C, the noticeable heat losses must be
calculated. These fuel losses indicate that it is necessary
to increase coke lumpiness in operating furnaces at an in-
creased gas pressure, to pay a greater attention to the
maintenance of cast iron caps and to the limitation of slag
tuyere dimensions.

Blast-furnace output is in a considerable measure deter-
mined by the preparation of ore materials. In the solution
of this problem the control of the process of iron ore refin-
ing and of agglomerate sintering is an important link. The
utilization of radioactive isotopes has proved to be very
effective in this field also.

At the Kuznetsk Iron and Steel Works a radiometer was
desinged for the determination of the agglomerate density.
Instrument operation is based on the absorption of radioactive
emission of isotopes. Instrument tests at the agglomerate
plant have shown that it may be used for the control of the
process of ore sintering in obtaining the agglomerate.

Further rationalization of the method and development of
reliable installations for the control of the properties of
coke,ore and agglomerate offer a possibility to obtain data in
relation to the aerodynamic resistance of the charge. The use
of radiometric installations for controlling the density of

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coke, ore and agglomerate permits to increase blast-furnace
output,and also creates new prerequisites for the automation
of laborious processes and for the sanitation of the condition
of labour.

3. Determination of the Speed of Motion and of the
Time during which the Charge stays in the Blast-Furnace

For a number of years on several plants in the Soviet
Union is the motion of charge materials in blast-furnaces
controlled. This work is of great practical value for the
control of the blast-furnace process and for the determination
of optimal duties of furnace operation and of a rational shaft
profile.

For the study of the motion of the charge by means of
radioactive isotopes two particular methods are used. The
first method (the method of measuring the radioactivity of
tests of melt products) determines the total time during which
the materials are in the furnace - from the instant of loading
to their getting into the hearth and their dissolution in
cast iron. In this case materials are carried into the furnace
in the zone of the top at a definite time prior to the output
of cast iron. The time of their getting into the hearth is
established by the appearance of radioactivity in the cast
iron. This method requires no special equipment, but it offers
no possibility for the determination of the speed of the
incoming charge on seperate sections of the furnace shaft.

The time during which various charge materials stay at
a desired point in the furnace was determined on furnaces or
a variety of volumes and designs. Tests at the Novo-Tulsk
Plant have shown that in the zone of the body and in the
lower section of the shaft there is a ring of slowly-moving

materials,which lessens the actual working volume of the
furnace by 10-15%. This information is partially corroborated
by limestone tests at the "Azovstal" Plant. The mean speed
of lowering materials, in a number of cases, was greater in
in the centre of the furnace than at the periphery - directly
at shaft walls, which depends both upon the system of loading
and upon the physical properties of charge materials. The
relative alteration of the mean speed along radii of two fur-
naces of the "Azovstal" Plant is shown on Fig. 5. On the blast-
furnace A the speed increases continuously from the periphery
to the centre, while on the blast-furnace B it reaches a ma-
ximum at a distance about 0.46 m from the shaft wall, and
becomes less and less thereon. In both cases the speed is
higher in the centre than at the periphery.

The second method - of radiometric sondage (developed by
Fellows of NTMP , the Dzerzhinsk Plant and CSRIFMI) - permits
to determine the speed of individual components of the charge
on any section of the shaft. The diagram of the test in the
study of the speed of motion of the charge with eight points
of investigation is shown on Fig. 6. Radioactive granules of
the charge were brought in to the level of filling, at a
desired distance from the centre of the furnace, while at ho-
rizons I - VI were introduced radiometric soundings consisting
of a system of three coaxial pipes, between which there is
provided the circulation of water, which maintains in the in-
terior pipe a temperature not more than 40°. In the interior
pipe, which is sealed hermetically against the seepage of
moisture, there is arranged a radiation detector (a self-quen-
ched counter).

When traced charge granules are lowered from the upper
horizon, the radioactivity is recorded in succession on the

lower horizons. The speed with which the charge is moving on separate sections of the furnace is determined by the time intervals between maximum intensity of radiation, which correspond to the passage of a granule through two adjacent horizons, or by the speed of the growth of intensivity at each horizon. For the location of the detector three variants are used: a. Outside the shaft, at the furnace hood; b. In the shaft lining; 3. In the interior of the furnace.

The method of radiometric sondage was used on large volume furnaces. Tests revealed the displacement of the charge to the furnace centre at the second horizon, which was somewhat greater for coke than for ore. Between the second and third horizons both coke and ore deflect towards the periphery, the coke further than the ore. In the lower portion of the shaft materials also get displaced towards the periphery. In the axial zone the speed at which the materials were lowering was in some sections higher than at the periphery. In the tuyere zone the movement of materials was investigated by means of soundings inserted through the tuyeres. It was found that radiation sources in one minute both approach the tuyere nozzle and move away from it many times.

In the study of the motion of limestone on a furnace of medium volume it was found that the speed with which it moves decreases while it is being lowered; the limestone speed is maximal between the first and second horizons. In the lower part of the shaft at a distance of about 3.7 m from the wall limestone gets lowered faster than at the periphery: the lowering speed at a datum 20,520 at the periphery was 3 M/h, while at a distance of 2.5 m from the wall it was about 5.5 m/h.

4. Motion of Cast Iron in a Hearth of a Large Blast-

Furnace

By the method of radioactive indicators may be investigated both the intermixing of smelting products and the motion of cast iron in the blast-furnace hearth.

The method is based on the following principle. A radioactive isotope phosphorus-32 is introduced through the tuyere into the liquid cast iron and slag, which is in the hearth. Conclusions as to the nature of the motion of cast iron in the hearth are reached by the results of measurement of radioactive probes selected in definite time intervals. The present work was conducted at the Ilich Plant blast-furnace having a volume of 1,719 cu. metres. The results of investigation are shown on Fig. 7. Different amounts of the radioactive indicator were applied in different tests. Therefore, on the axis of ordinates of Fig. 7 is laid off the radioactivity of samples expressed in percentages of the maximum radioactivity for each test. The weight of cast iron output is taken to be 100%, while the time of selection of cast iron samples is also shown in relative units, taking into account the duration of the output.

On the basis of the investigation made it was established that in the intervals between outputs cast iron in the hearth of the blast-furnace is mixed poorly. Some mixing and evening out of the temperature of cast iron and of the chemical composition takes place, in the main, in the period of its outlet, as a result of the motion of cast iron in the hearth, and while it passes through the cast iron tap. When it is let out of the blast-furnace hearth, cast iron comes out first from the region of the cast iron tap and last of all from the region

of the hearth at the side of air heaters. In this process the upper layers of cast iron move considerably faster than the lower ones. When the central part of the furnace operates actively and when the cast iron tap is in a normal state, the rate with which the hearth is freed of cast iron is the same both for a furnace with a volume of 1,033 cu m and for a furnace with a volume of 1,719 cu m. Practically from 10 to 15% of cast iron, which did not come out during the output of cast iron, remains in a blast-furnace, which has a useful volume of 1033-1719 cu m, which does not influence to any considerable degree the operation of the furnace.

From the point of view of completness of outflow of cast iron out of a furnace during output there is no need in providing a second cast iron tap for furnaces with a volume of 2,286 cu m having a 10.3 m hearth diameter. When the furnace has a larger output and cast iron is let out frequently, the normal working state of the tap can be ensured by the utilization of high-quality carbon steel for the tap and of powerful electrical guns (with an 80 kg/cm^2 piston pressure).

Cast iron is completely changed in the furnace on an average of from 2 to 3 outputs, although some insignificant amount of cast iron still remains in the furnace. That is one of the factors conditioning both the thermal inertia of a blast-furnace hearth and the gradual change of the chemical composition of cast iron.

The change of the temperature of cast iron while the output proceeds is one of the indications of the completeness with which the hearth is being freed of smelting products. During cast iron output, especially on a large furnace, the inconsiderable and temporary cooling of cast iron, which

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evidences a local cooling of the hearth, remains unnoticed,
just the same as the beginning of important cooling of the
hearth. For the prevention and timely liquidation of possible
coolings and for the maintenance of a more stable heat state
of the hearth it is necessary to keep up constantly a greater
heat in the central part of the hearth and to heat the hearth
from tuyere to tuyere evenly, by means of selecting the cor-
responding systems of loading and operating duty of the ro-
tating charge distributor, as well as to equip the blast-
furnaces with instruments for the automatic measurement and
recording of the temperature of cast iron and slag in the run
of the output.

5. Control of the Scouring of the Lining of Blast-Furnaces

At a number of plants the methods of radioactive inserts
and of radioactive sondage are used for controlling the wear
of lining of the hearth bottom and of the shaft of blast-
furnaces, in order to investigate the strength (resistance to
wear) of refractories and select a rational design of the
blast-furnace.

By the utilization of radioactive indicators quantitative
data on the wear of a definite layer of shaft lining of a
blast-furnace can be otained and the time required for the
destruction of the given layer determined.

The use of radioactive isotopes in the study of the wear
of blast-furnace hearth bottom linings led to the mastery of
the dynamics of wear and permitted to set up a rational shape
of the hearth bottom.

Hearth bottoms, which are cylindrical in form and have
coolers along the periphery of the lower part, have the grea-
test strength. Hearth bottoms having the shape of a trunca-

ted cone offer less favourable conditions for cooling and get
destroyed quicker. It was found advisable to use radioactive
isotopes for the control of scouring of blast-furnace hearth
bottoms in those cases when the hearth bottom installed is of
a new design. Lately such an investigation was conducted at
the Ilich plant, where the hearth bottom was made of a high-
strength high-aluminous brick. Preliminary results indicate
that such a hearth bottom is stronger than a chamotte hearth
bottom. Due to the data of this work Design Offices have
provided stronger hearth bottoms.

II. STEEL SMELTING

1. The Study of the Absorption of Sulphur Out of
Gasous Fuel in Smelting Steel in Open-Hearth Furnaces

At the Stalinsk Iron and Steel Plant the mixed coke and
blast-furnace gas, used in heating the Open-Hearth furnaces,
has before the headpiece from 5 to 8 g of sulphur per cu m,
while before it enters the head - about 0.8 g of sulphur per
cu m. In the process of smelting the sulphur is from its gase-
ous phase partially transformed into metal, due to which its
concentration in finished steel is raised.

Below are presented: a description of the method of deter-
mination of the amounts of sulphur, which pass from the gas
into the charge in smelting in Open-Hearth furnaces at the
Stalinsk Plant, and of the results obtained by it.

The method is based on the determination of the weight
of liquid metal and liquid slag in the furnace in the process
of smelting and upon a subsequent preparation of a material
balance, by sulphur, with the utilization of the data of
chemical analyses of samples of both metal and slag.

The weight of both metal and slag is determined by the method of Isotope Dilution. In experimental melts a radioactive cobalt in a non-metallic state was introduced, to an amount of 0.1 m Cu per ton of metal, into liquid cast iron before it is poured into the Open-Hearth furnace. In the process of smelting metal samples were selected in the furnace and poured into the cast iron mould. Cylindrical ingots so obtained were placed in the centre of a protecting chamber, along whose circumference 12 gas counters were arranged. As the melting went on the radioactivity of metal samples kept on decreasing due to the increase of the amount of metal in melting scrap.

The weight of the total amount of liquid metal in tons M_t in the furnace at the time instant t was calculated from the results of measurements of ingot radioactivity by means of the following equation:

$$M_t = \frac{M_o \cdot i_o}{i_t} \quad , \text{ where}$$

M_o – is the weight of the liquid cast iron poured into the furnace, in tons;

i_o – is the speed of counting from a sample of that cast iron, in imp/min.g.;

i_t – is the speed of counting from a sample of metal selected out of the furnace in a time instant t, imp/min.g.

The change of weight of liquid metal in the run of one of the experimental melts is shown graphically on Fig. 9.

For the determination of the weight of liquid slag in the furnace radioactive calcium was used; it was placed into metal cartridges as CaO and arranged on the surface of solid charge materials on the bottom of the Open Hearth before cast iron was poured. The Ca^{45} content in the final slag was 7 m Cu per ton.

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As the melting went on slag samples were taken. The measurements of calcium radioactivity in slag samples, together with the calculation of the weight of the wetted slag, permitted to determine the weight of liquid slag in the furnace in the process of smelting.

On Fig. 10 on coordinates counting speed - time is given the curve of dilution of radiocalcium in slag in one of the experimental melts.

In all test melts slag was weighed after the melt was completed and the ingot weight determined. That permitted to correct results of radioactivity measurements. The totality of experimental data on radioactivity and of the results of the chemical analysis of all samples of metal and slag for sulphur content permitted to make up balance sheets of melts for that element. Thus, the amount of sulphur, which went over from the fuel into the charge, can be determined as the difference between the actual weight of sulphur in the metal-slag system and the weight of sulphur carried into the furnace along with charge materials.

12 melts have been investigated by the method described. It was found that during the periods of heaping up, warming and pouring cast iron the open-hearth bath consumes on the average about 3 kg of sulphur per hour, or approximately 11 kg during that entire period. That makes up approximately 15% of the total weight of sulphur in the metal-slag system.

During the melting period the bath consumes somewhat more of sulphur, the amounts consumed increasing with the growth of the sulphur content in the mixed coke and blast-furnace gas.

The results of calculations indicate that during the period of metling, the metal, on an average, absorbs about 11 kg

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of sulphur from the fuel, while in the period of final melt-
ing about 1.5 kg of "gaseous" sulphur passes over from the
metal into the slag. In all during the melt from fuel into
steel passes over about 20 kg of sulphur, which is approxima-
tely 0.015%.

Usually in melts made under conditions as described above
the ready metal has a sulphur content of 0.045%. Thus, on
the average, approximately one third of that amount is the
component that gets into steel from the fuel. However, if we
turn from average values to the consideration of individual
melts, then we will note that in some cases during the period
of final melting there is observed a considerable decrease of
the sulphur content in the metal. So, in one of the test
melts in this period about 13 kg of "gaseous" sulphur was re-
moved from the steel, i.e., almost 0.010%. The result obtained
indicates that there is a possibility to considerably lower
the steel sulphur content by means of bettering the slag
regime. It was found that the greatest negative effect upon
the process of desulphuration is produced by the slag silica
content, the silica entering the slag from the ore charged
into the furnace. In that connection the Stalinsk Plant intro-
duced the practice of changing a part of the ore by cinders,
which contain no silica. Such a modification of the technology
ensures a substantial lowering of the metal sulphur content
and a lessening of the duration of melts.

At the present time operations, in w. ch the weight
of liquid steel in the furnace has to be determined, are
carried out by the utilization of radioactive ruthenium in
place of radiocobalt. In that determination the intensity
of radiation of metal samples is measured by means of a scin-

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tillation counter, which permits to decrease more than an
order the concentration of the radioactive isotope in the
metal.

2. The Study of Slag Formation in Smelting Steel in Large Open-Hearth Furnaces

The "Azovstal" Iron and Steel Plant processes cast iron
with a high phosphorus content. Therefore, the rationalization
of the Open-Hearth furnace slag regime is of especial interest
to it, in oder to most effectively dephosphorise the metal,
as well as to obtain slags with a high content of phosphorus
pentoxide, used as agricultural fertilizer.

In the open-hearth shop a technology was specified, by
which in the furnace, after the ready steel is let out, some
amount of slag is left. That measure is aimed to fascilitate
the formation of slag during the melting period in the next
melt. The optimal conditions for the utilization of such a
slag were worked out by means of the method of radioactive
isotopes. To the slag, which was left in the furnace, radioac-
tive sulphur was added, and then, as the process of melting
was being carried on, slag samples were taken. By the results
of measurements of the radioactivity of these samples it was
established that the earlier the slag, which was left over in
the furnace, begins to melt, the more successful is the flow
of the dephosphorization process.

In this connection the idea occurred that the openhearth
slag, which is skimmed from the furnace in the final period
of bath refining, may again be used in subsequent melts as a
slag forming material. In this case the slag, which previously
was dumped on the heap, now becomes a circulating material,
which permits to reduce the consumption of limestone. Besides,

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the use of such a formed slag should fascilitate the melting
of ore and limestone charged into the furnace and, therefore,
should better the conditions of dephosphorization of metal
during the initial period of melting.

Below are described tests on Open-Hearth furnaces of
the "Azovstal" Iron and Steel Plant, in which the speed of
melting of the circulating slag and its effect upon the run
of melting were determined. For that purpose the circulating
slag was traced with radioactive phosphorus. From 30 to 40
minutes before the last polished slag was skimmed, into the
metal bath have been introduced a few grams of iron phosphide
enriched P^{32}. In the interval up to the end of the melt radio-
phosphorus was oxidized and was uniformly spread in the liquid
slag volume. When poured out of the furnace the slag was
subjected to crushing in the ram engine shop to sizes of 50-
100 mm and was then used in melts. The amount of this slag,
which was charged into the furnace, was from 1.5 to 4% by
weight of the metallic part of the charge.

The judgment of the speed of melting of the solid slag
was made by the radioactivity of slag samples, which were
taken from the furnace in the process of melting. Tests have
shown that the first samples of slag, taken directly after
the pouring of cast iron, were characterized by a maximal
radioactivity. That can be illustrated on Fig. 11, on which
is given a curve indicating the variation of radioactivity
of slag samples with the run of the melting. From an analysis
of this Fig. it follows that the circulating slag almost
entirely passes into the liquid state directly after the
pouring of the cast iron into the furnace. Thus, an analysis
of the above mentioned tests shows that the use of circula-

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ting slag should lead to the contraction of the duration of melting. A comparison of melts made by the usual and by the new technology corroborated that assertion. It showed that in the last case on the average the duration of melts has been lessened considerably. Taking into account the lessening simultaneously of the consumption of limestone, it may be considered that the new technology possesses important economic advantages. At the present time it is being mastered by the plant.

3. The Effect of the Quantity of Slag Upon the Quality of Steel in the Period of Pure Boiling

At the "Azovstal" Iron and Steel Plant the radioactive isotope of phosphorus was also utilized for the determination of the weight of slag in an open-hearth furnace in the period of pure boiling. Radiophosphorus was introduced into the furnace in the middle of that period. The weight of slag was determined by the measurement of the radioactivity of its samples.

Tests have shown that the flow of processes of steel melts and the quality of the ready metal both depend upon the quantity of slag in the furnace. So, Fig. 12 shows that the speed of oxidation of carbon, when all other conditions are the same, is a maximum for mean quantities, of slag comprising about 6% of the weight of the metal. Both for greater and for smaller quantities of slag the oxidation is retarded.

It is interesting to note that with such an optimal quantity of slag in the furnace there also is observed a maximal speed in the heating of the metal and a highest output of steel of the first class. That can be illustrated by Fig. 13, on which the output of first class rails is shown to be a function of the weight of slag in the furnace.

Conclusions

The examples presented in the report indicate the effect--
iveness of the utilization of radioactive isotopes in the so-
lution of technological problems of metallurgical production.

The further advance of works on the utilization of the
attainments of nuclear physics for the benefit of metallurgy
will, seemingly, to a considerable degree depend upon the re-
sults of the activities of scientists and engineers in the
field of physics of the isotopy of elements and of nuclear
radiation, as well as the achievements in the design of radio-
metric apparatus and of individual nuclear physics installa -
tions.Here should, in the first place, be named such questions
as the availability of radioactive and stable isotopes of a
series of light elements, which can be handled conveniently,
the design of high-sensitive portable radiometric apparatus
which will make possible to conduct measurements on a wide
range of temperatures, the creation of small-size powerful
neutron sources. With greater intensity should the development
of questions connected with radiation safety in working with
isotopes and radiation, under conditions of industrial produc-
tion, be continued. Exchanges of experiences obtained in
various countries on the above-indicated questions of applied
nuclear physics may suostantially accelerate the advance of
this field of science and technique.

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Figures

Fig. 5. Distance from wall, mm.

Fig. 6. 1) Horizons;

2) To tuyere No. 8;

3) To tuyere No. 9;

4) To tuyere No. 8;

To horizons I-V.

Fig. 7. 1) Radioactivity of cast iron tests, %%;

2) Weight of cast iron melt, %%.

Fig. 9. 1) Scrap smelting melt No. 3161;

2) Weight in tons;

3) Time in minutes.

Fig.10. 1) Melt No. 3149;

2) Dilution Ca^{45};

2) $I \frac{imp.}{min.}$;

3) Time, min.

Fig.11. 1) $\frac{imp.}{min.}$;

2) Time, hour-min;

3) Pouring

I   II   III

cast iron

Fig.12. 1) 0 - rail steel

X - low carbon steel;

2) Speed of burning of carbon, % Cmin.;

3) Percent of slag from weight of metal.

Fig.13. 1) Percent of first class rails;

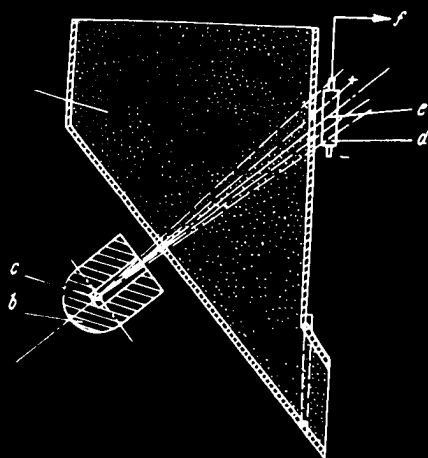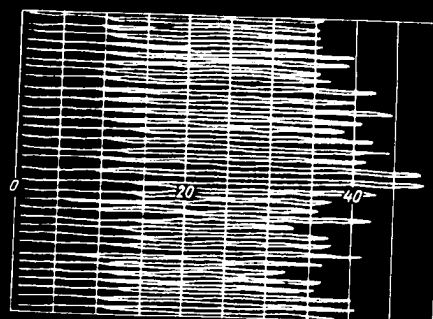2) Percent of slag from weight of metal.
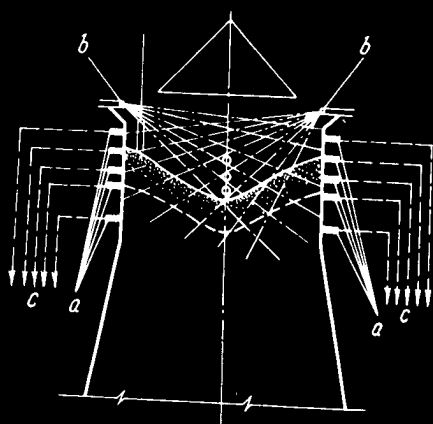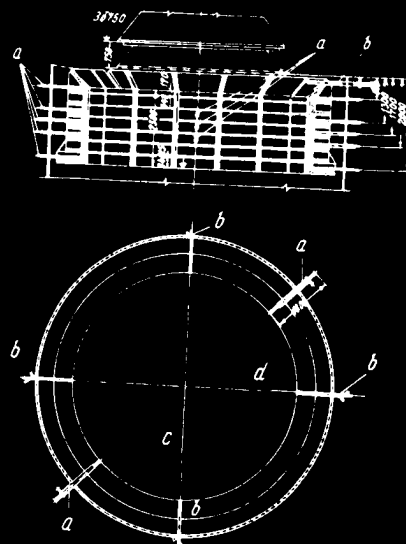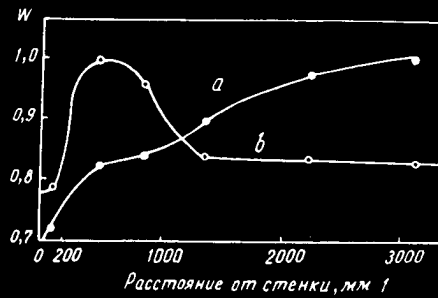
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Рис. 1

Рис. 2

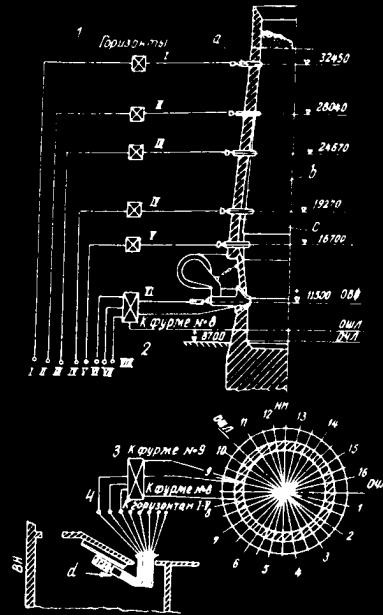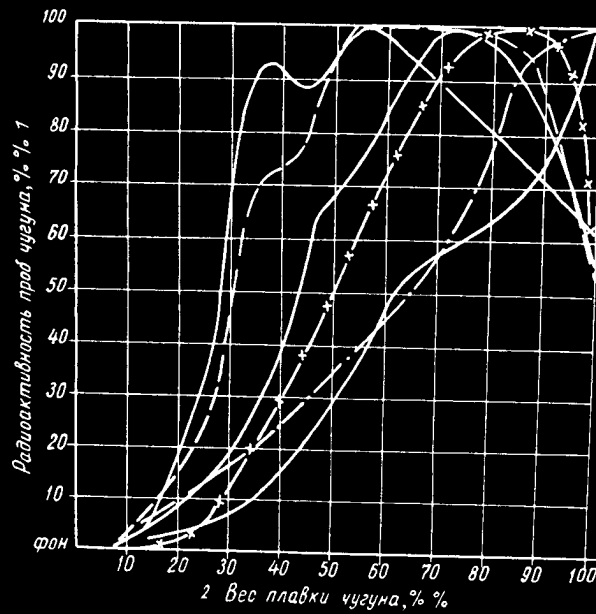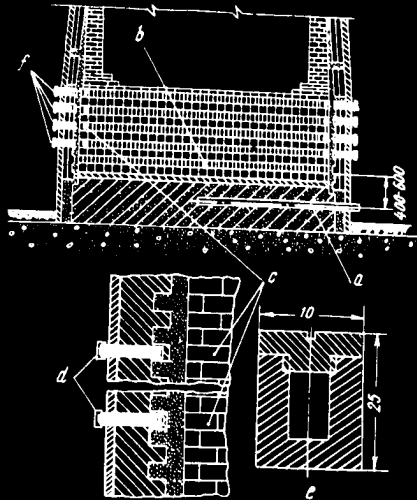Рис. 3

Рис. 4

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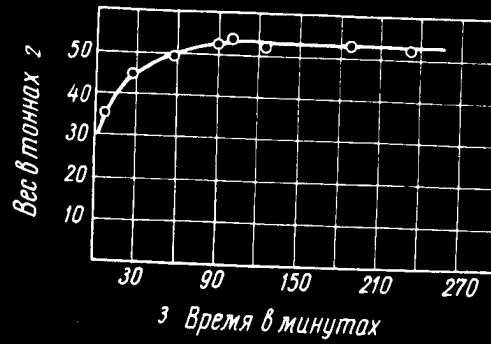
Рис. 5

Рис. 6

Рис. 7

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Рис. 8

1 ПЛАВЛЕНИЕ СКРАПА
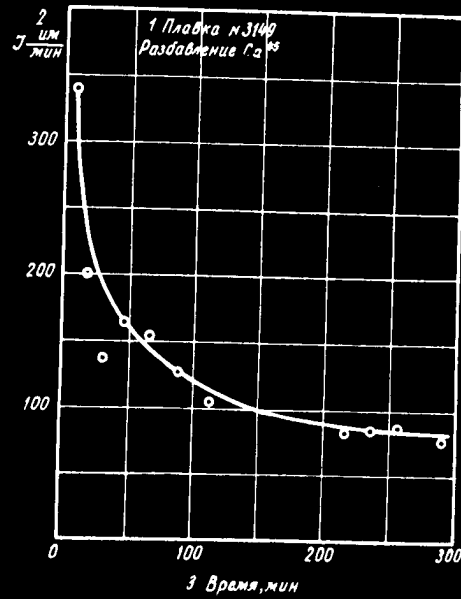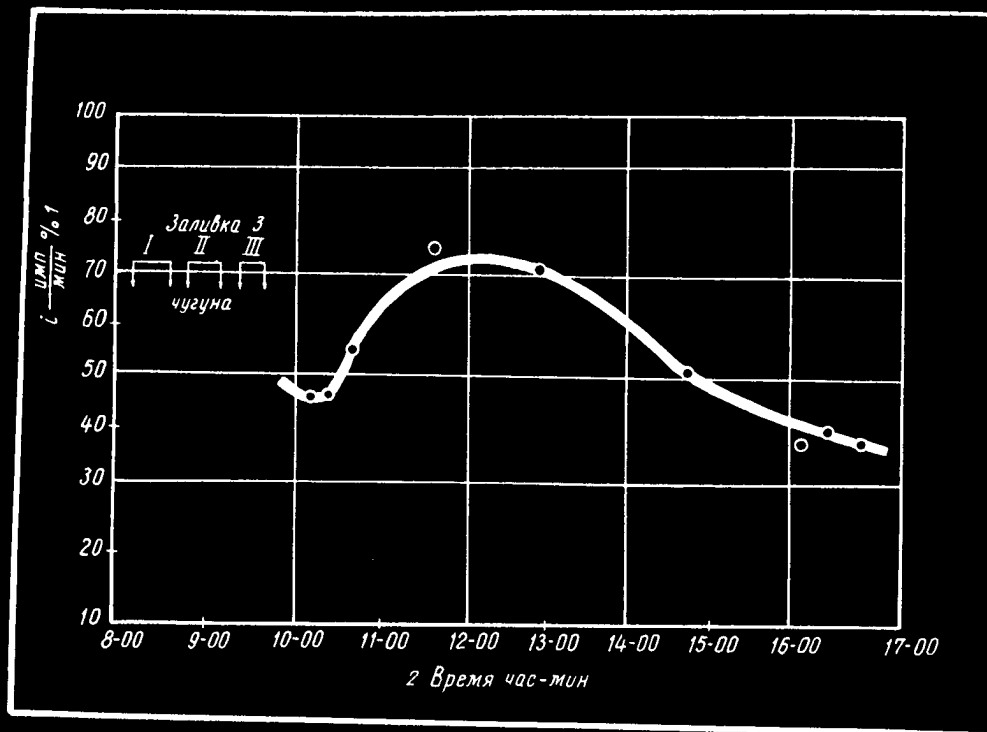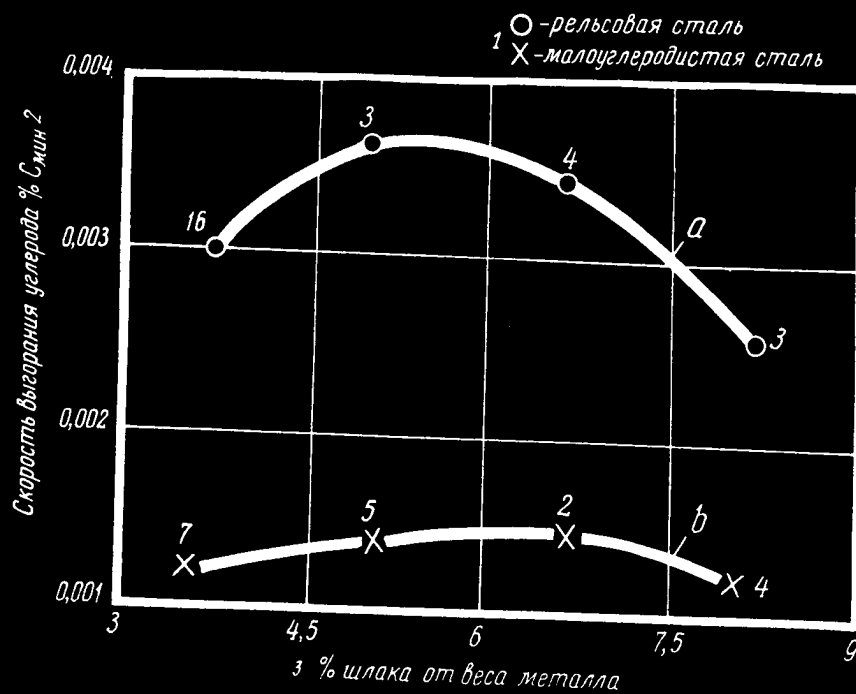ПЛ. N 3161

Рис. 9

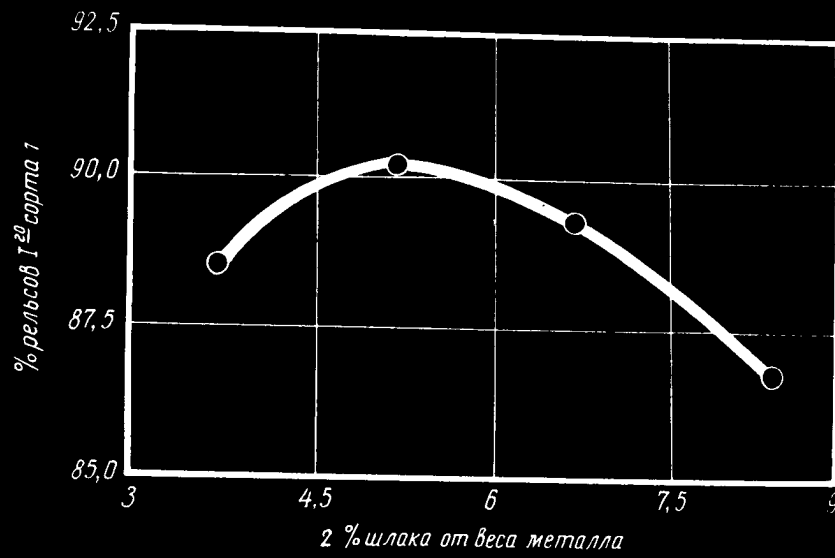Рис. 10

Рис. II

Рис. 12

Рис. I b

THE USE OF IONIZING RADIATION FOR MODIFYING THE
PROPERTIES OF WOOD AND SYNTHETIC POLYMERS
by V.L.Karpov, A.S.Freidin, Y.M.Malinskij,V.I.Serenkov,
R.S.Klimanova

A practically important trend in the field of radiation
chemistry is the research into the use of nuclear radiation
to obtain new types of polymeric materials. To this heading
belongs the work in polymerization and the study of the
effect of nuclear radiations on natural and synthetic poly-
meric materials; radiation vulcanization and graft-polymeriza-
tion; and the production of block-polymers through irradiation.

Great emphasis has been laid in the recent period on the
development of methods of how to apply nuclear radiation to
produce graft- and block-polymers. The principal process under-
lying these methods is a modification of the properties of
polymeric materials either by "grafting" chains of a different
chemical composition and structure to the molecular chains of
polymers or by producing block-polymers of varying structure.
Among the methods known so far of producing grafted co-polymers
the least elaborated is the method of irradiating mixtures of
polymers in solid state or in solution.

The application of ionizing radiations for processing and
modifying wood and other materials is based, on the one hand,
on an examination of properties of the irradiated wood and
on the other - on employing radiation polymerization and graft-
polymerization.

Of greatest interest is the modification process of wood
and other fibrous or porous materials after previously impregna-
ting them with a monomer. An irradiation following the impreg-

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nation produces a radiation polymerization of monomers and in some cases even a formation of grafted polymers, the resulting products having a different set of properties.

Some of the characteristic advantages of this technique are: a possibility of performing the process at room temperature, atmospheric pressure, and without using catalists and initiators, and a low viscosity of monomers, a factor which fascilitates the impregnation process.

By varying the choices of monomers, the extent of their impregnating the fibrous base, and the conditions of irradiation it is possible to obtain materials with extremely different properties which combine the characteristics of the initial product with those of the polymer formed.

We have studied in particular the modification of wood by polystirene, polymetilacrilate, polymetilmetacrilate, polyvinilacetate and polyacrilonitril . The most interesting results are observed when the polymer can be solved in its monomer.

If compared with popular kinds of wood plastics (DSP, delta-wood a.o.) this material is characterized by full retention of the cell structure of wood presenting a framework which is filled with the newly formed polymer.

Below are given the properties of modified wood (pinewood, modified with polystirene). The volume weight of the material increases from 0,46 to 0,61 when the amount of stirene absorbed is 20,5% of the weight of wood and from 1,0 to 1,1 when the wood has absorbed 120% of polystirene.

Table 1 shows varying strength caracteristics of such wood.

Polystirene: 120% of the weight of wood

Dose rate: 22 rad/sec

Property	Integral dose, 10^{-6} rad		
	0	15,5	50
Resistance to compression along fibre, kg/cm^2	325	920	1050
Resistance to static bending, kg/cm^2	845	1400	1135

It wollows from Table 1 that the most substantial impro-
vement of strength corresponds to the integral dose of
$15,5.10^{-6}$ rad. Further irradiation deoreases the resistanoe
of wood against static bending which is a result of atlera-
tions occuring in wood itself due to γ-rays (see below).

Along with the integral dose the intensity of irradiation
is of major importance for the qualities of the product obtai-
ned.

As is shown in Fig. 1▾2, the formation in the wood of
such a water-resistant polymer as polystirene decreases more
than twofold the maximum moisture absorption of wood and more
than sixfold-its water absorption. The maximum water absorption
(within 30 days) of such wood is not more than 25%, and the vo-
lume increase due to moisture absorption (see Table 2) is twice
less as compared to the initial material.

<u>T a b l e   2</u>

Change of volume in determining moisture absorption

of pine-wood modified with polystirene

Integral dose $15,5.10^{-6}$ rad

	Time, days							
	1	2	3	5	8	13	20	30
Change of volume of modified wood, % of the initial	4,2	6,5	5,4	7,4	4,9	8,2	6,8	6,9
Change of volume of basic wood, % of the initial	9,7	11,8	11,2	14,0	12,9	15,0	14,0	15,0

The wood modified with polyacrilonitril posesses high fire resistance and will not give food to burning. Thus the above method makes it possible to obtain from both hard and soft wood varieties such meterials which differ from the initial ones by increased strength,chemical resistance, a lower water and moisture absorption and a greater dimension stability. Such a wood is fungi-resistant and, using appropriate polymers, is provided with better dielectrical qualities.

Materials of this kind may find many applications in building, transport, engineering, electric and radio industry. In particular, a specially conducted test of the adequacy of wood modified with polystirene for making casting models (bearing model 350x150x200 mm) has shown that after 18 days in moulding earth such models practically do not change their shape or dimensions and absorb twice less moisture than samples not processed. They have several characteristics superior to models protected by other techniques.

The polymerization of monomers by ionizing radiation can be performed not only in wood but also in other fibrous materials: textiles, paper etc. with considerable alteration of qualities resulting. An interesting application of this method of material modification is the conservation of all kinds of museal and archeological treasures composed of fibrous material by using radiation polymerization.

The development of a practical application of ionizing radiation for wood modification has been made possible due to extensive research into the radiation acting on the lignin-carbo-hydrate complex and its components. The change of the mechanical properties of various wood varieties has been studied with great detail, and the dose limits leading to an essential decrease in wood strength have been difined (Table 3).

Apparently, these dose-rates are considerably higher than those necessary for modifying wood by radiation polymerization and graft-polymerization.

γ-radiation results in somewhat higher rates of water absorption (though its maximum value remains coustant) and a certain decrease of water vapour absorption (2-3%) by wood.

The change in the mechanical properties of irradiated wood is caused by radiation-chemical processes which take place in irradiated materials. These processes result in a higher solubility of these materials in water which is in the main a consequence of a destruction of the polysaccharides macro-molecules down to the level of low-molecular products.

The radiolisis affects in the first place the hemicellu-loses and among these – the pentosans, with cellulose second. Lignin is the most radiation resistant component protecting carbo-hydrates from radiolisis.

In scale of radiation resistance the polysaccharides are to be arranged as follows:

araban < xylan < mannan < galactan < cellulose

As is known, lignin is responsible for the resistance of wood against compression, while the cellulose and the hemicelluloses in the first rate make it resistant against splitting and bending stresses. That accounts for the irradiated wood working better against compression and worse against bending and splitting.

We have also studied the possiblities of using nuclear radiation for producing new types of polymers based on mixtures of high pressure polyethilene and block-polystirol.

The initial polyethilene and polystirene were mixed by rolling at $140^{o}C$, in weight proportions 90: 10 (PS - 10); 80:20 (PS - 20); 50:50 (PS - 50) respectively.

From these rolled mixtures samples for irradiation and subsequent test were prepared by casting or pressing. The irradiation of samples was made using a Cobalt^{60} source of 21.000 g.eq. of Ra, at $20^{o}C$ and $130^{o}C$ with and without atmospheric oxygen.

The samples were tested for tension strength and elongation in tension prior to and after the irradiation. The change of the specific impact toughness was also measured. In the latter test there was no destruction of the PS - 10 nor PS - 20 samples neither prior to, nor after the irradiation.

The changes in the mechanical properties of the polymers concerned after their irradiation are presented in Table 4. The total quantity of ungrafted and non-cross-linked polystirene was determined by extracting irradiated samples with toluol in a Soxhlet apparatus for 12 hours.

The Effect of Ionizing Radiation on the Strength of Some Wood Varieties

Property	Integral Dose										
	0	10		50		100		300		500	
	Strength limit kg/cm²	Strength limit kg/cm²	Change of strength, %	Strength limit kg/cm²	Change of strength,%	Strength limit kg/cm²	Change of strength,%	Strength limit kg/cm²	Change of strength,%	Strength limit kg/cm²	Change of strength,%
Resistance to compression											
Pine-wood	350	360	0	385	+5,5	350	-4	320	-12,5	250	-33
Asch-wood	520	-	-	-	-	450*/	-16,5	410**/	-21	-	-
Beech-wood	655	-	-	-	-	570	-18,5	500	-24	-	-
Resistance to splitting											
Pine-wood	75	70	-6,5	57	-24	39	-48	32	-57	22	-70
Asch-wood	150	-	-	-	-	105	-30	100**/	-34	-	-
Beech-wood	85	-	-	-	-	-	-	27**/	-68	-	-
Resistance to statical bend											
Pine-wood	825	800	-3	660	-20	370	-55	250	-70	83,5	-90
Asch-wood	920	-	-	-	-	-	-	230**/	-64	-	-

*/ Dose-rate 140.

**/ Dose-rate 380.

Table 4

Change of Mechanical Properties of Polymers Due to Irradiation

Type of material	Non-irrad. Tension strength, kg/cm² (6)	Non-irrad. Elongation in tension,% (3)	Non-irrad. Specific impact toughness, kg/cm²	Dose-rate 100 (6)	Dose-rate 100 (3)	Dose-rate 200 Specific impact toughness, kg/cm²	Dose-rate 200 (6)	Dose-rate 200 (3)	Dose-rate 300 Specific impact toughness, kg/cm²	Dose-rate 300 (6)	Dose-rate 300 (3)	Dose-rate 400 Specific impact toughness, kg/cm²	Dose-rate 400 (6)	Dose-rate 400 (3)	Dose-rate 500 Specific impact toughness, kg/cm²	Dose-rate 500 (6)	Dose-rate 500 (3)
Polyethilene	111	350	-	-	-	-	155	80	-	161	70	-	160	50	-	-	-
PS - 10	90	75	-	163	69	-	172,5	65	-	200	54	-	175	45	-	169	40
PS - 20	88	62	-	113	35	-	161	23	-	176	20	-	183	20	-	168	15
PS - 50	78	57	14	92	10-15	27,2	161	5-7	53,5	-	-	-	162	5-7	61	160	5-

Though part of the ungraited and non-cross-linked polysti-
rene could not be extracted because it was immobilized in
cross-linked polyethilene,the measurement was adequate for
making certain conclusions about the interaction of polyethi-
lene and polystirene during the irradiation.

In particular, an examination of the extract of a sample
PS - 10 which had received a dose of 60.10^{-6} rad has shown
that under the conditions above mentioned not only the whole
of the polystirene contained in the sample is extracted but
also 8-10% of polyethilene.

Part of the polyethilene thus extracted (50-60%) is pre-
cipitated when the extract is cooled. The remaining 50-40%
of the extracted polyethilene is isolated during fractiona-
tion by adding methyl alcohol to the extract in quantities
insufficient for the precipitation of polystirene.The findings
of the elementary analysis of this precipitate testify to
an interaction of polyethilene and polystirene taking place
during irradiation. The fact of such interation is also con-
firmed by the results of thermo-mechanical tests of irradi-
ated and non-irradiated polystirene,polyethilene, PS - 10,
PS - 20, and PS - 50. In the PS - 10 and PS - 20 samples which
had recieved for example a dose of $500-700.10^{-6}$ rad a certain,
though not considerable, increase of the elasticity module is
observed in atmospheric conditions as against that for pure
polyethilene, which fact can be accounted for solely by an
interation of polyethilene and polystirene during irradiation.

The irradiated mixtures of polyethilene and polystirene
show a 35-40°C increase in the temperature of change to con-

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dition of high elasticity as compared to the temperature of the initial mixtures changing to viscous condition. An examination of the solubility of irradiated pure polyethilene and its mixtures with polystirene has shown that polystirene produces a stabilizing effect on polyethilene as a result of which the rate of tying polyethilene in the presense of polystirene decreases.

We have also examined the thermal stability of the samples PS - 10, PS - 20, and PS - 50 which had been irradiated in the air with a dose of 1000.10^{-6} rad, by heating them at $250^{o}C$ for 4-6 hours. In all cases a change of colour was observed but no change of form, of the samples.

In order to achieve a fuller combination of polystirol, and polyethilene, reduce the viscosity of the medium and make condition more favourable for an interaction of polyethilene and polystirol, we irradiated samples of PS - 10, PS - 20 and PS - 50 at a temperature of $130^{o}C$. At this temperature the above mixtures of polyethilene and polystirol changed, according to visual observation, to homogenous and transparent melts.

However, at these conditions, intense gase formation occured during irradiation which resulted in porous materials. Thus, by irradiating mixtures of polyethilene and polystirol at room temperature one can obtain new types of polymeric materials with improved strength and thermal stability characteristics (up to $250^{o}C$).

The resulting irradiated materials are not amenable to konwn technological processing techniques and the method

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of increasing thermal stability and strength characteristics just described is only applicable to previously shaped products.

Materials of this kind may find application in radio-engineering and electrotechnicks and also where it is necessary to improve radiation stability of a product made for instance of polyethilene.
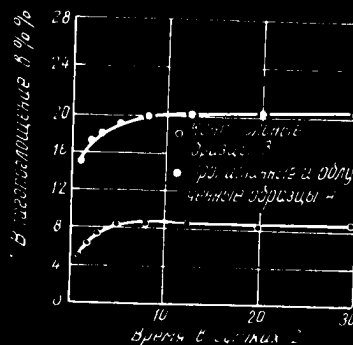
Fig. 1. Change of moisture absorption of initial and modified wood (on a time basis).

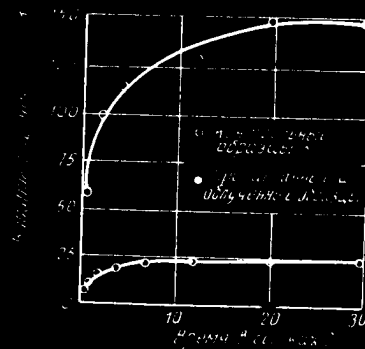1 - Moisture absorption, %; 2 - Time, days; 3 - Control samples; 4 - Impregnated and irradiated samples.

Fig. 2. Change of water absorption of inital and modified wood (on a time basis).

1 - Water absorption, %; 2 - Time, days; 3 - Control samples; 4 - Impregnated and irradiated samples.